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Title: BS to BS coexistence between Band 12/17 and additional new 716-728 downlink
Document for: Discussion

1. Introduction

The WI proposal to support the New Band LTE Downlink FDD 716-728 MHz was approved in RAN#50 [1]. And the revised WID was approved in RAN#51 [2]. One objective of the WIs is to specify the band-combinations specific Radio Frequency (RF) requirements for inter-band CA of Band 2, 4 or 5 plus additional new 716-728 downlink. Note that we will denote the additional new 716-728 downlink as Band A for convenience.

In this paper, we investigate the coexistence issue between Band 12/17 Base Station (BS) and Band A BS from the 3GPP requirements perspectives.

2. Discussion

The frequency ranges of the current Bands 12 and 17 uplink (UL) and downlink (DL) defined in the 3GPP standards [3] as well as the proposed DL-only Band A are shown in Figure 1 below.

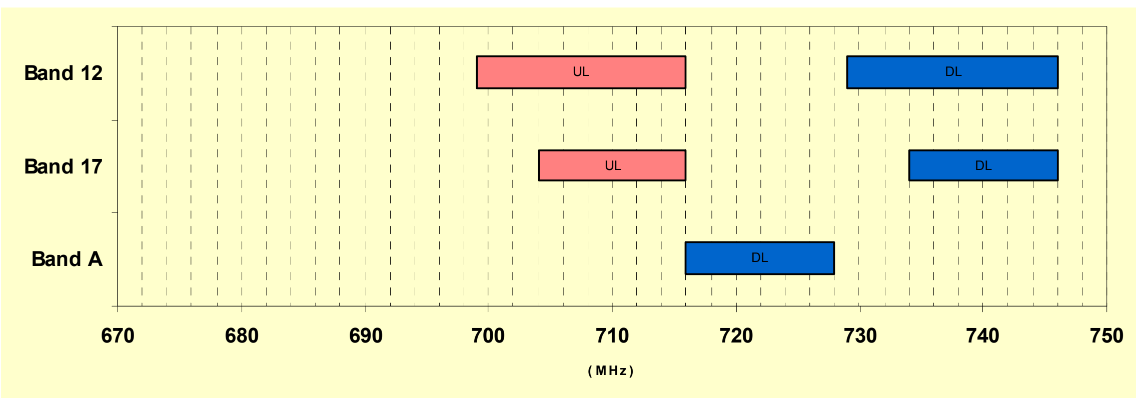

Figure 1: Frequency ranges of Bands 12, 17 and A

It can be seen from Figure 1 that the most challenging BS to BS coexistence issue is at 716 MHz where Band 12/17 UL is adjacent to Band A DL. To allow Band 12/17 BS to coexist (in the same geographical area) or co-locate with Band A BS, the operators should ensure the following:

- The Band A BS transmitter unwanted emissions received by the Band 12/17 BS do not cause unacceptable Band 12/17 BS receiver desensitization.
- The total Band A BS carrier power attenuated by the Band 12/17 BS receiver RF, IF and baseband filters do not result in the Band 12/17 BS receiver blocking.

2.1 Transmitter unwanted emissions

Currently, the BS spurious emissions limits for co-existence (in the same geographical area) with BS operating in other frequency bands is specified as -49 dBm/MHz in the UL frequency range of the operating band of the coexisted BS [3]. This requirement value is obtained assuming a 67 dB BS to BS minimum coupling loss (MCL) and a 0.8 dB victim BS receiver desensitization [4]. The calculation for 5 MHz and 10 MHz channel bandwidths is shown in Table 1 below.

Table 1: Calculation of spurious emission limits for BS coexistence

Thermal Noise power spectral density	dBm/Hz	-174	
BS noise figure	dB	5	
Channel bandwidth	MHz	5	10
Noise bandwidth	MHz	4.5	9
Receiver noise floor	dBm	-102.47	-99.46
BS Spurious emissions limits (co-existence)	dBm/MHz	-49	
BS-BS MCL (co-existence)	dB	67	
Receiver interference (co-existence)	dBm	-109.47	-106.46
Receiver interference + noise floor (co-existence)	dBm	-101.68	-98.67
Receiver sensitivity degradation (co-existence)	dBm	0.79	0.79

If we assume the out-of-band (OOB) emission from the power amplifier (PA) is designed to meet the -13 dBm/MHz specified in the Multi-Standard Radio (MSR) specification [4] so that the BS can also be used for UTRA operation, then the required rejection by the BS RF transmit (TX) filter to meet the -67 dBm/MHz emission limit will be (67 – 13 =) 54 dB.

Moreover, the BS spurious emissions limits for co-location with BS operating in other frequency bands is specified as -96 dBm/100 kHz in the UL frequency range of the operating band of the co-located BS [3]. This requirement value is obtained assuming a 30 dB BS to BS MCL and a 0.8 dB victim BS receiver desensitization [5]. The calculation for 5 MHz and 10 MHz channel bandwidths is shown in Table 2 below.

Table 2: Calculation of spurious emission limits for BS co-location

Thermal Noise power spectral density	dBm/Hz	-174	
BS noise figure	dB	5	
Channel bandwidth	MHz	5	10
Noise bandwidth	MHz	4.5	9
Receiver noise floor	dBm	-102.47	-99.46
BS Spurious emissions limits (co-location)	dBm/100kHz	-96	
BS-BS MCL (co-location)	dB	30	
Receiver interference (co-location)	dBm	-109.47	-106.46
Receiver interference + noise floor (co-location)	dBm	-101.68	-98.67
Receiver sensitivity degradation (co-location)	dBm	0.79	0.79

Again if we assume the OOB emission from the PA is designed to meet the -13 dBm/MHz specified in the MSR specification [4] so that the BS can also be used for UTRA operation, then the required rejection by the BS RF TX filter to meet the -96 dBm/100 kHz emission limit will be (96 – 10 – 13 =) 73 dB.

From the above discussion, it can be seen if the OOB emission from the PA is -13 dBm/MHz, then the Band A BS RF TX filter must provide 54 dB and 73 dB, respectively, to coexist (with 67 dB MCL) and co-locate (with 30 dB MCL) with Band 12/17 BS receiver. It is impractical to achieve these levels of rejection without any gap between the Band A DL and Band 12/17 UL. However, up to 4 MHz gap between the Band A DL and Band 12/17 UL could be obtained by putting the

UL carrier at the lower edge of the allocated frequency block and the DL carrier at the higher edge of the allocated frequency block. The carrier arrangement is shown in Table 3 below. Note that the unused frequency range at each edge inside the channel bandwidth (0.25 MHz and 0.5 MHz, respectively, for 5 MHz and 10 MHz channel bandwidth) are not included in Table 3.

Table 3: Possible gap between Band 12/17 UL and Band A DL

Band 12/17 frequency block (FCC allocation)	Band A frequency block (FCC allocation)	Band 12/17 UL carrier (MHz)	Band A carrier (MHz)	DL<->UL Gap (MHz)
C	D	710 – 715	717 – 722	2
C	D+E	710 – 715	718 – 728	3
B+C	D	704 – 714	717 – 722	3
B+C	D+E	704 – 714	718 – 728	4

With the at least 2 MHz (2.5 MHz including unused frequency inside the channel bandwidth) gap available by carrier arrangement as shown in Table 3 above, it could be feasible for the Band A BS RF TX filter to provide the required rejection to coexist or co-locate with Band 12/17 BS receiver, with small degradation in other aspects of the filter performance (e.g. insertion loss and modulation accuracy). However, the increase in cost, size, weight, and complexity of the filter still need to be considered. Other alternatives to achieve the same Band 12/17 BS receiver desensitization of 0.8 dB include reducing the OOB emission from the Band A PA and increasing the coupling loss (i.e. antenna isolation) from Band A BS TX antenna connector to Band 12/17 BS receive (RX) antenna connector.

2.2 Receiver blocking

Now we look at the Band 12/17 BS receiver blocking requirements in order to avoid receiver blocking by the Band A DL carrier power. Currently, the interfering signal power for the BS adjacent channel selectivity (ACS) requirement is specified as -52 dBm for a 6 dB victim BS receiver desensitization [3]. These requirement values mean that the minimum rejection by the Band 12/17 BS receiver IF and baseband filters on the adjacent channel interferer is 45.72 dB for 5 MHz channel bandwidth, as the BS RF filter cannot provide any rejection in the in-band frequency range. The calculation for 5 MHz channel bandwidth is shown in Table 4 below. Note that the calculation in Table 4 is also valid for 10 MHz channel bandwidth because the same reference measurement channel as for 5 MHz channel bandwidth is specified for the ACS requirement.

Table 4: Calculation of BS ACS requirement

Thermal Noise power spectral density	dBm/Hz	-174
BS noise figure	dB	5
Channel bandwidth	MHz	5
Noise bandwidth	MHz	4.5
Receiver noise floor	dBm	-102.47
Interfering signal power (ACS)	dBm	-52
Receiver sensitivity degradation (ACS)	dB	6
Allowed receiver interference (ACS)	dBm	-97.72
Required receiver filter rejection (ACS)	dBm	45.72

Moreover, the interfering signal power for the BS in-band general blocking requirement is specified as -43 dBm for a 6 dB victim BS receiver desensitization [3]. This interfering signal level is applied from the lower frequency of the BS receive band minus 20 MHz to the upper frequency of the BS receive band plus 20 MHz. These requirement values mean that the minimum rejection by the Band 12/17 BS receiver IF and baseband filters on the in-band interferer is 54.72 dB for 5 MHz channel bandwidth, as the BS RF filter cannot provide any rejection in this in-band frequency range. The calculation for 5 MHz channel bandwidth is shown in Table 5 below. Again the calculation in Table 5 is also valid for 10 MHz channel bandwidth because the same reference measurement channel as for 5 MHz channel bandwidth is specified for the in-band general blocking requirement.

Table 5: Calculation of BS in-band general blocking requirement

Thermal Noise power spectral density	dBm/Hz	-174
BS noise figure	dB	5
Channel bandwidth	MHz	5
Noise bandwidth	MHz	9.00
Receiver noise floor	dBm	-102.47
Interfering signal power (general blocking)	dBm	-43
Receiver sensitivity degradation (general blocking)	dB	6
Allowed receiver interference (general blocking)	dBm	-97.72
Required receiver filter rejection (general blocking)	dBm	54.72

Comparing the required receiver filter rejection levels in Tables 4 and 5, it can be seen that the BS receiver IF and baseband filters could provide (54.72 – 45.72 =) 9 dB more rejection when the interfering signal is 5 MHz further away from the wanted signal. This will mean 1.8 dB/MHz more rejection if we assume a constant slope in the filter transfer function within this frequency range.

On the other hand, the interfering signal power for BS blocking performance requirement when co-located with BS in other frequency bands is specified as 16 dBm for a 6 dB victim BS receiver desensitization [3]. Again this requirement value is obtained assuming a BS output power of 46 dBm and a 30 dB BS to BS MCL [5]. These requirement values mean that the minimum rejection by the BS receiver RF, IF and baseband filters on the co-located BS DL signal is 113.72 dB for 5 MHz channel bandwidth. The calculation for 5 MHz channel bandwidth is shown in Table 6 below. Again the calculation in Table 6 is also valid for 10 MHz channel bandwidth because the same reference measurement channel as for 5 MHz channel bandwidth is specified for co-location blocking requirement.

Table 6: Calculation of BS co-location blocking requirement

Thermal Noise power spectral density	dBm/Hz	-174
BS noise figure	dB	5
Channel bandwidth	MHz	5
Noise bandwidth	MHz	4.5
Receiver noise floor	dBm	-102.47
Interfering signal power (co-location blocking)	dBm	16
Receiver sensitivity degradation (co-location blocking)	dB	6
Allowed receiver interference (co-location blocking)	dBm	-97.72
Required receiver filter rejection (co-location blocking)	dBm	113.72

Now if we use the more conservative ACS rejection by the Band 12/17 BS receiver IF and baseband filters on the co-located BS A DL signal, then the required rejection by the Band 12/17 BS RF RX filter to meet the co-location blocking requirement will be (113.72 – 45.72 =) 68 dB. It is impractical to achieve this level of rejection without any gap between the Band 12/17 UL and Band A DL. However, as discussed above and shown in Table 3, up to 4 MHz gap between the Band 12/17 UL and Band A DL could be obtained by putting the UL carrier at the lower edge of the allocated frequency block and the DL carrier at the higher edge of the allocated frequency block.

With the at least 2 MHz (2.5 MHz including unused frequency inside the channel bandwidth) gap available by carrier arrangement as shown in Table 3 above, the Band 12/17 BS receiver IF and baseband filters should provide more rejection than ACS, and it could be feasible for the Band 12/17 BS RF RX filter to provide the required rejection to co-locate with Band A BS transmitter, with small degradation in other aspects of the filter performance (e.g. insertion loss). However, the increase in cost, size, weight, and complexity of the filter still need to be considered. Other alternatives to achieve the same Band 12/17 BS receiver desensitization of 6 dB include increasing the IF and baseband filter rejection of the Band 12/17 receiver and increasing the coupling loss (i.e. antenna isolation) from Band A BS TX antenna connector to Band 12/17 BS RX antenna connector. In order to maintain same Band 12/17 BS receiver desensitization of 0.8 dB based on Band A BS transmitter emissions, the 30 dB MCL derived from Band 12/17 BS RX co-location blocking requirement should be increased to 42 dB.

3. Conclusions

In this paper, we have investigated the coexistence issue between Band 12/17 BS and Band A BS from the 3GPP requirements perspectives. We have shown that with the at least 2 MHz (2.5 MHz including unused frequency inside the channel bandwidth) gap available by carrier arrangement, it could be feasible for the Band 12/17 BS RX RF filters and the Band A BS TX RF filters to provide the required rejection to co-exist/co-locate with each other, with small degradation in other aspects of the filter performance (e.g. insertion loss and modulation accuracy). However, the increase in cost, size, weight, and complexity of the filters still need to be considered. Other alternatives to achieve the Band 12/17 receiver desensitization of 0.8 dB include reducing the OOB emission from the Band A PA, increasing the IF and baseband filter rejection of the Band 12/17 receiver, and increasing the coupling loss (i.e. antenna isolation) from Band A BS TX antenna connector to Band 12/17 BS RX antenna connector. Therefore, if at least 2 MHz gap will be available by channel arrangement of the Band 12/17 UL and/or Band A DL carriers, then we can reuse the same coexistence / co-location requirements for Band A as the other frequency bands specified in the 3GPP standards.

References

[1] RP-110435, "Work Item Proposal: New Band LTE Downlink FDD 716-728 MHz", AT&T.

[2] RP-110432, "Revised WID for New Band LTE Downlink FDD 716-728 MHz", AT&T.

[3] 3GPP TS 36.104 v10.3.0, "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".

[4] 3GPP TS 37.104 v10.3.0, "E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception".

[5] 3GPP TS 25.942 v10.0.0, "Radio Frequency (RF) system scenarios".